SYSTEMS ENGINEERING METHODOLOGY FOR FUEL EFFICIENCY AND ITS APPLICATION TO THE FUEL EFFICIENT DEMONSTRATOR (FED) PROGRAM

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GVSETS

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Agenda

- Fuel Efficient Demonstrator (FED) Program
- Total Vehicle Fuel Economy® process
- Complex Systems Modeling & Simulation
- Results
- Conclusions

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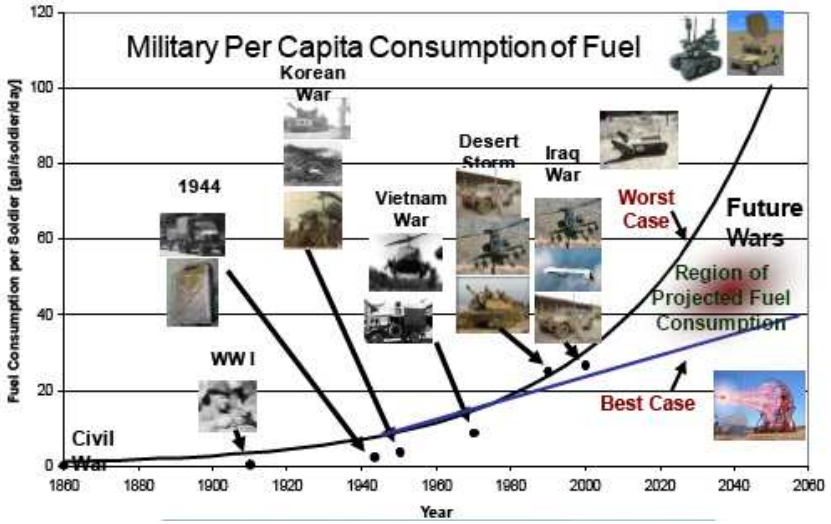
FED Background

- Initiative by Office of the Secretary of Defense to:
  - Improve vehicle technology to reduce fuel consumption on the battlefield
  - Reduce US dependence on oil

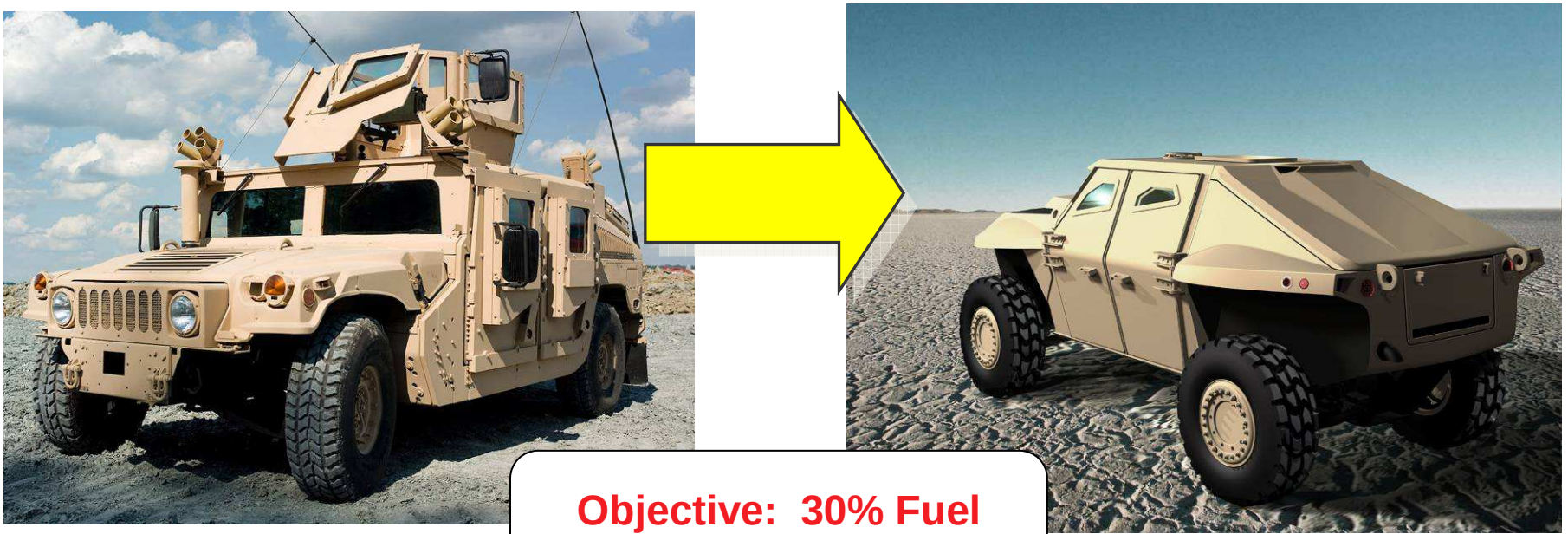


Source: Fuel Efficient ground vehicle Demonstrator (FED) Program Overview – FED Team / Carl Johnson – Sept 30, 2008

Source: http://www.army.mil/-news/2009/05/07/20777-army-saves-fuel-and-lives-by-bringing-new-life-to-an-old-technology/

FED Objectives

- To demonstrate a tactical vehicle with significantly greater fuel economy than an M1114 HMMWV while maintaining tactical vehicle capability



Objective: 30% Fuel Economy Improvement

Credible & Relevant Demonstrator Platform

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Fuel Economy:
- 7.5 mpg Composite
  - 12.6 mpg Convoy Escort
  - 7.1 mpg Urban Assault
  - 4.8 mpg Cross Country
  - 0.51 gpm Idle

Survivability:
- Integral V-hull
- Blast protected seating
- Upgradeable B-kit

Weight:
- 10,500 lbs VCW (A-kit)
- 15,400 lbs GVW

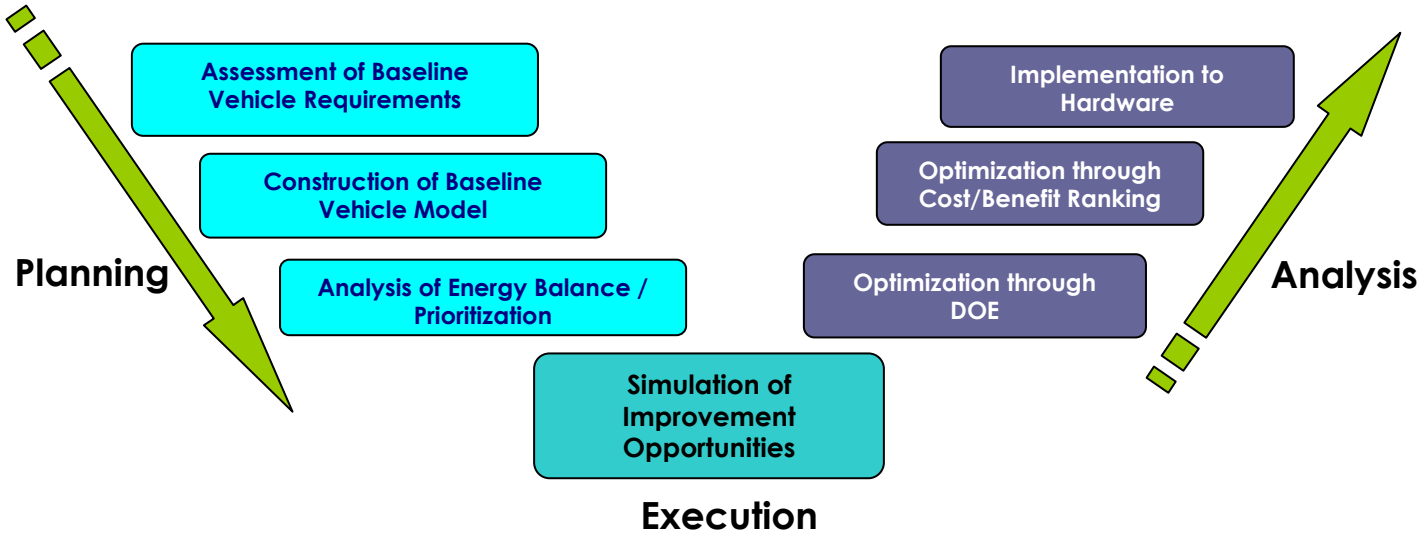
Performance:
- 50 mph Speed on 5% Grade
- 30kW Onboard Power

Mobility:
- 18” Step Climb
- 60% Grade

FED concept meets or exceeds M1114 HMMWV capabilities with 70+% better fuel efficiency

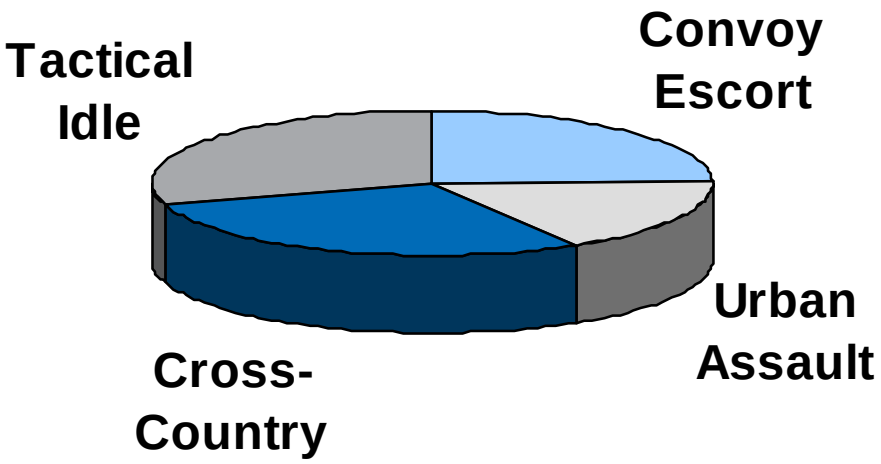
Total Vehicle Fuel Economy®

- A robust process flow with thorough planning and complete analysis of results.
- Successful and risk-managed strategy for product development.

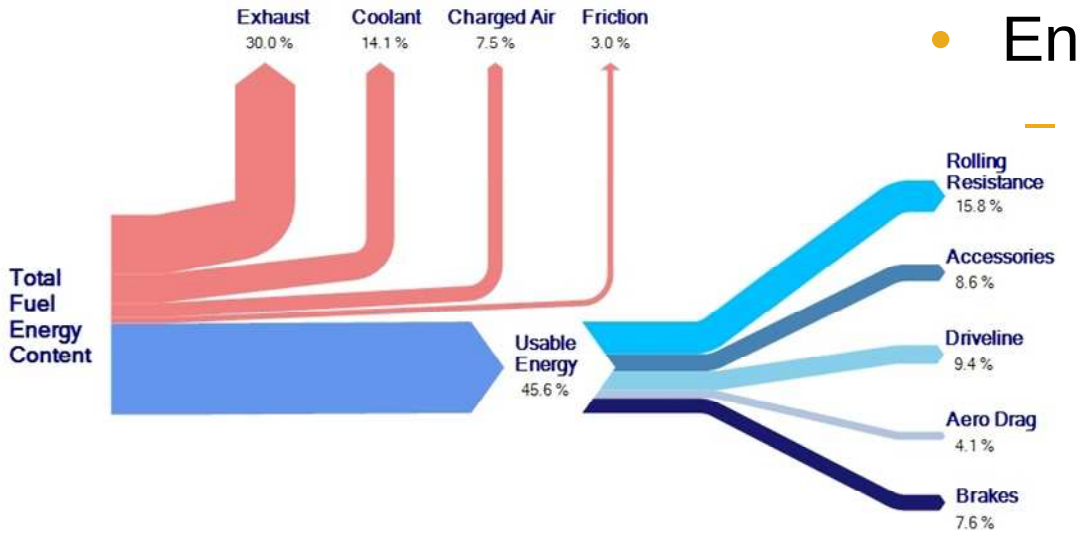


Usage Profile

- Unique military drive cycle developed for FED program with government input
- Criteria for quantitatively evaluating design alternatives
- Robust cycle
  - High & Low Speed
  - Flat & Grades
  - On & Off Road
  - Tactical Idle
- Focus on battle space

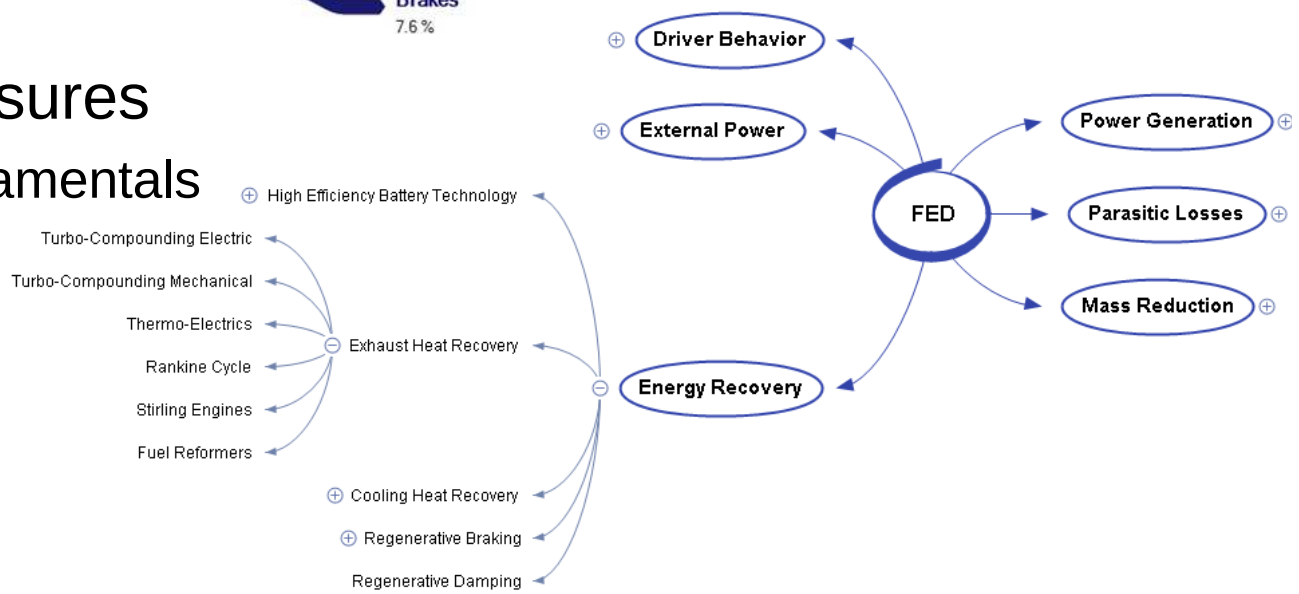


Prioritization Framework – Total Systems



- Energy Balance
  - Unique to vehicle & drive cycle

- Efficiency Measures
  - Mapping fundamentals



Technology Market Survey

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- Outreach efforts prioritized by energy balance results & subject matter expertise
- Opportunities primarily outside defense supply base
- Focus on key subsystem data to support modeling & simulation

Leverage for Improvements

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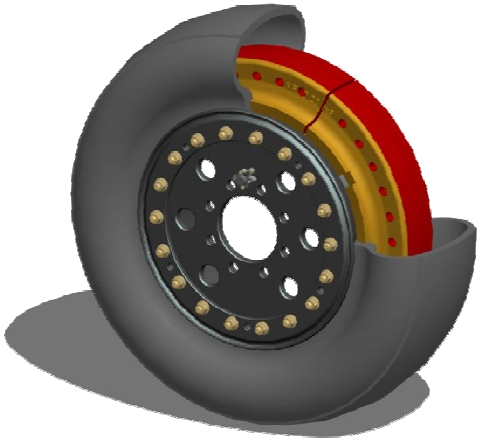
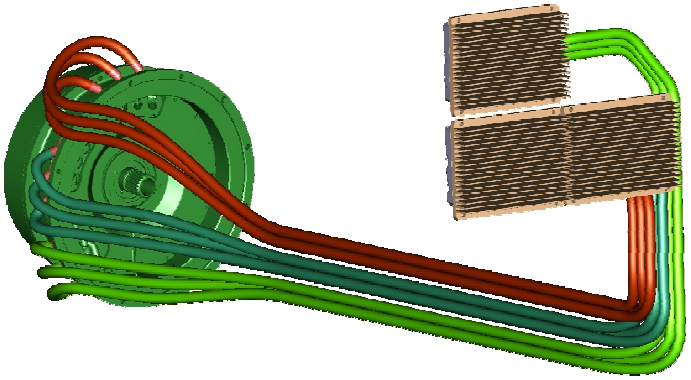
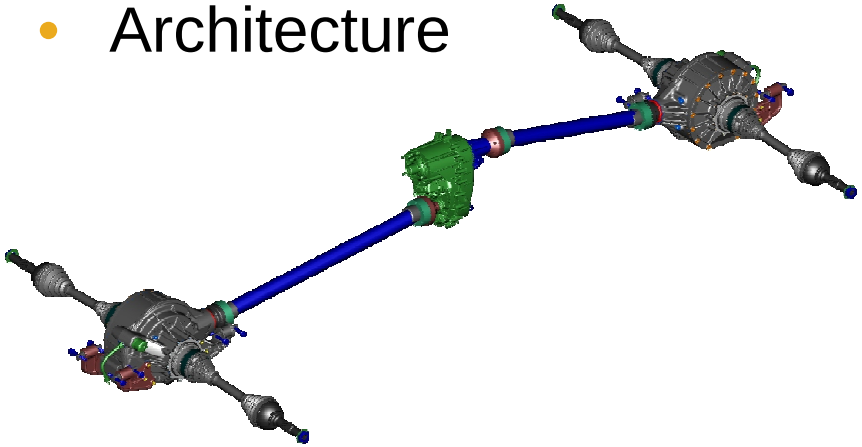
- Requirements



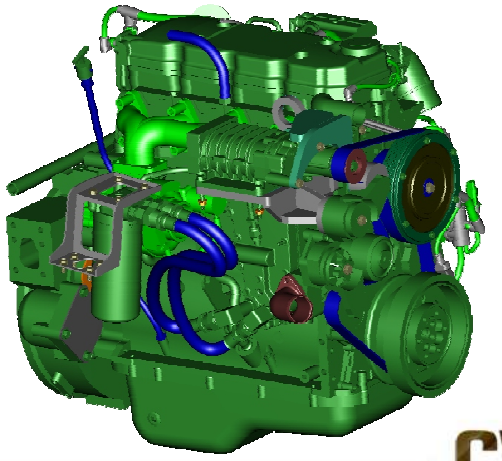
- Technology



- Architecture



- Specifications



Complex Systems Decision Tool

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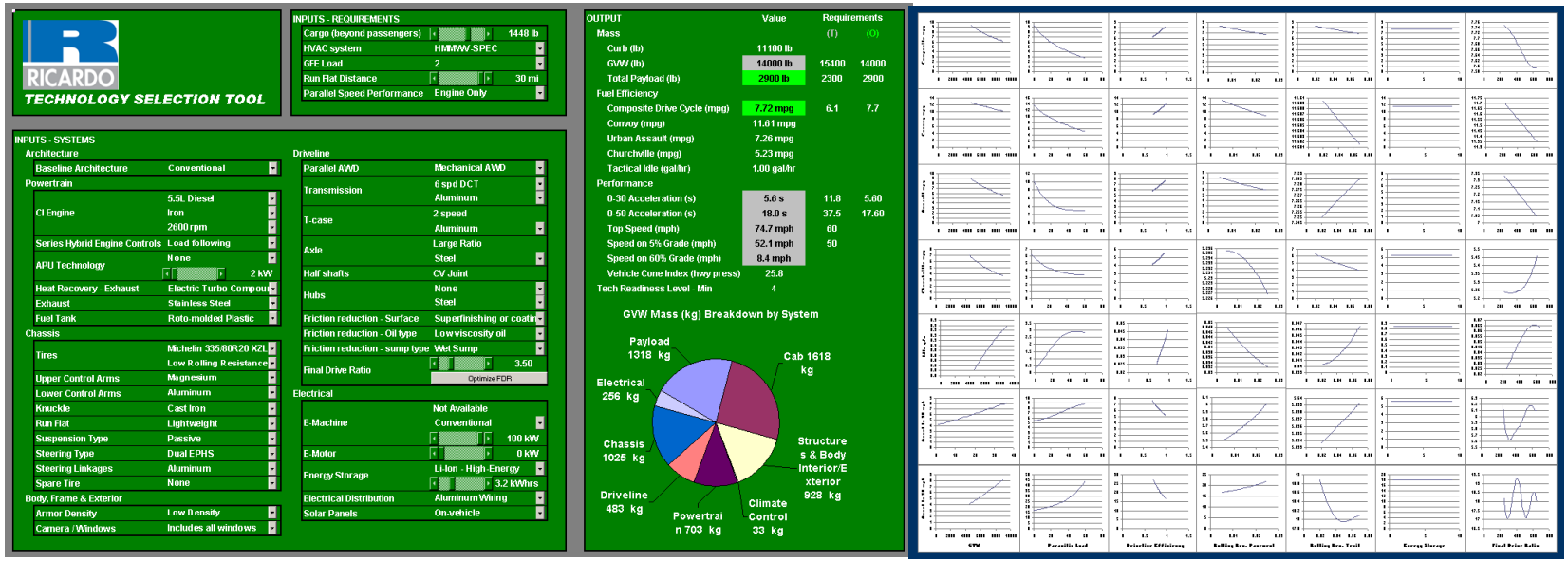
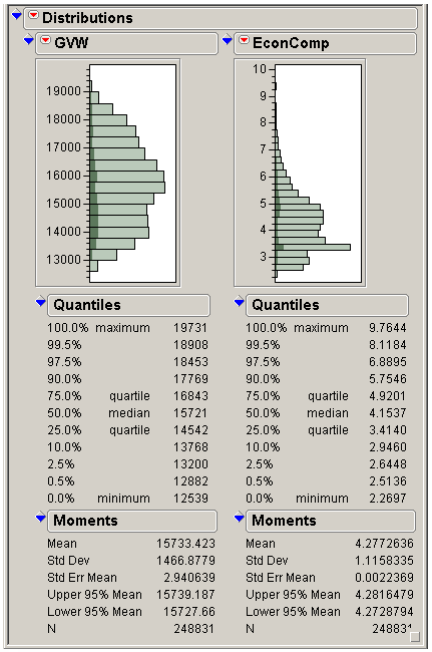
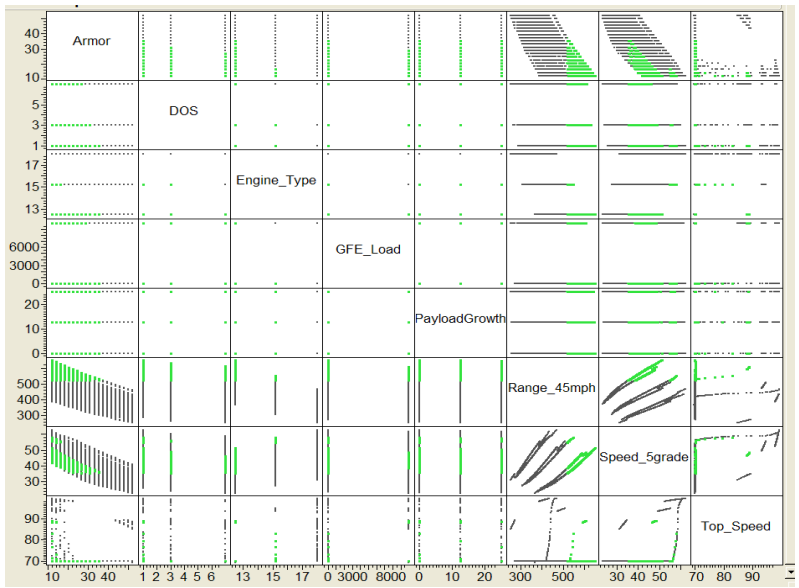
- Surrogate model based technology selection & vehicle performance toolset
  - Supplements traditional M&S tools by integrating them
  - Supports multi-attribute trade-offs
  - Real-time performance prediction & sensitivity

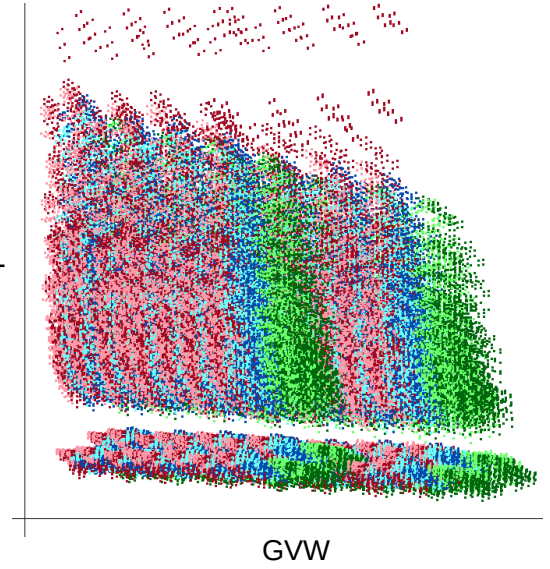


Design Space Exploration

- Surrogate models allow simulation of hundreds of thousands of feasible design configurations
  - Trade space definition
  - Filtering according to requirement scenarios
  - Generation of Pareto frontiers

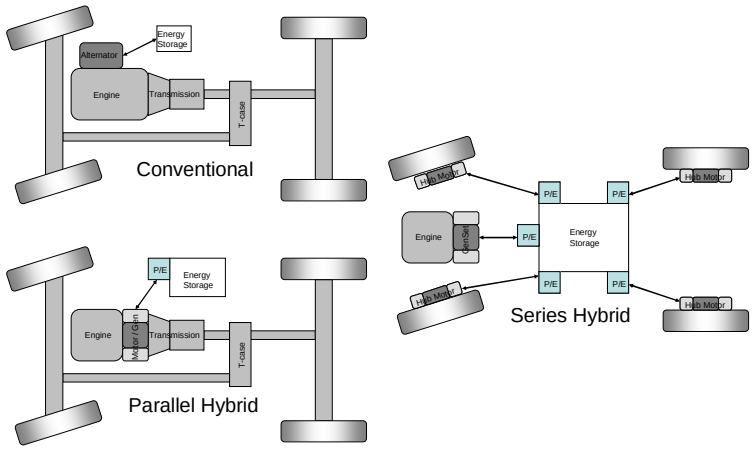






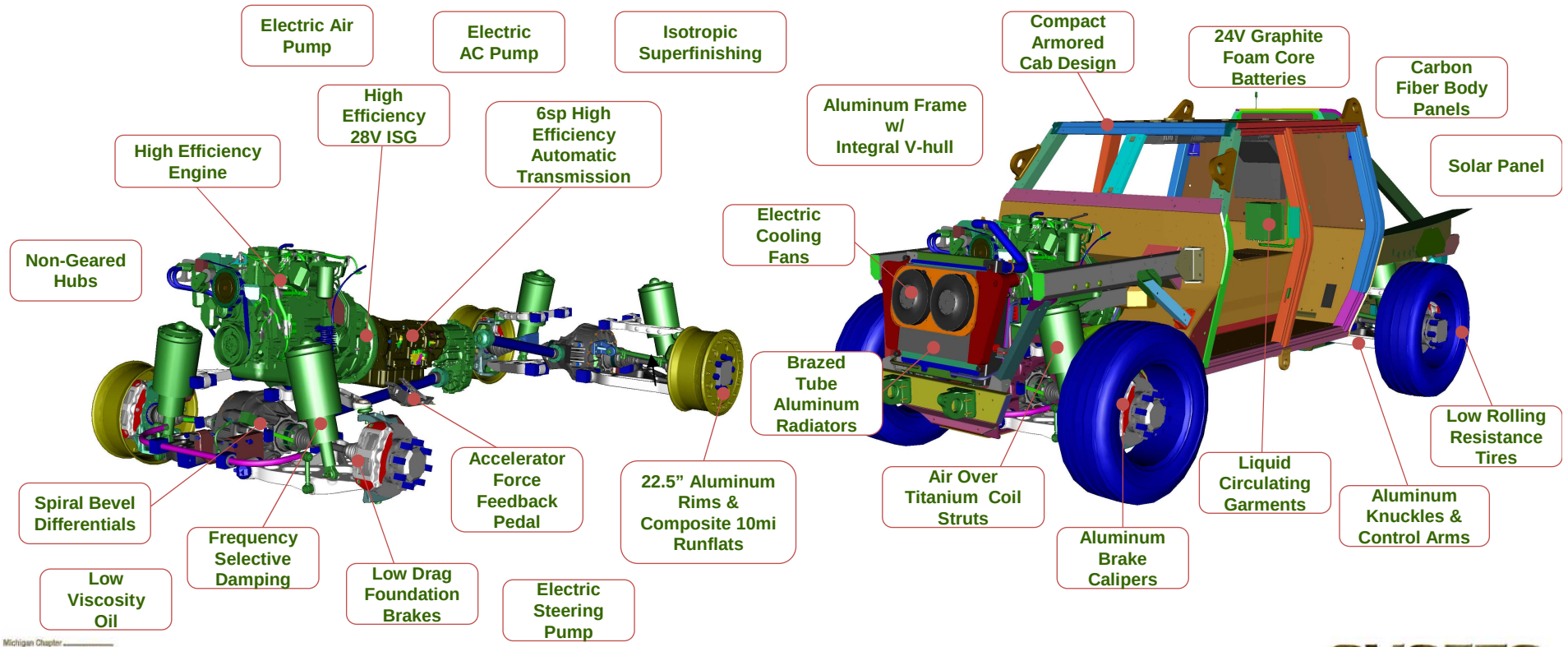
System Selection

- Pareto optimization
  - No optimal solution, only data driven trade-offs
- Normalization against requirement scenarios
  - Apples to apples comparisons
- Risk management
  - Unique issue for demonstration program
- Baseline concept development
  - Early mitigation of feasibility risks



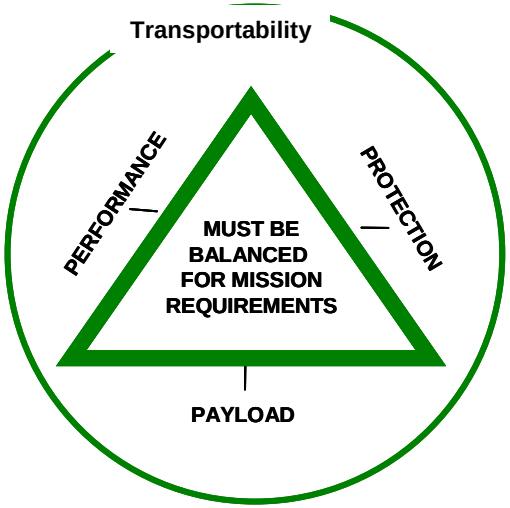
Results

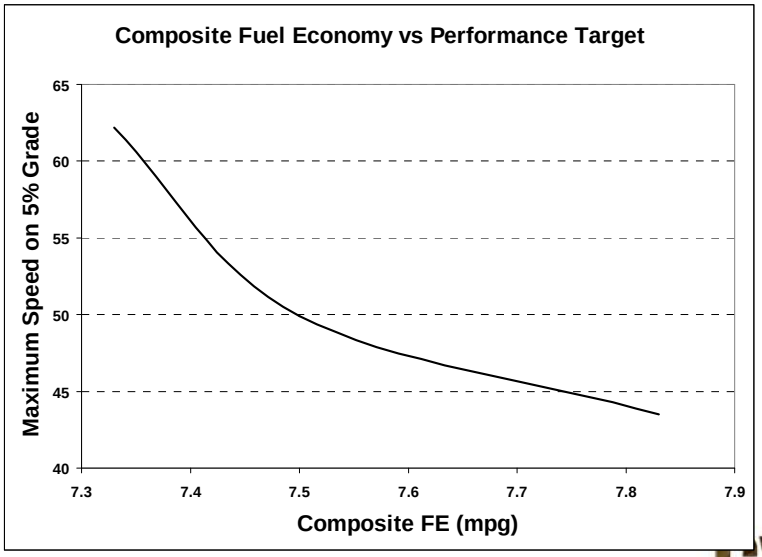
- Predicted 70% efficiency improvement vs M1114
- Roadmap to 110% identified for upgrades
  - Additional improvements outside drive cycle



Conclusions

- Critical for government staff to understand requirements sensitivities
  - "The realities of system development are that *EVERY requirement has a cost to implement and deliver*. Given limited resources and stakeholder values, bounding the *solution space* requires reconciling the cost of the desired requirements with the available resources." Source: Wasson, C. (2006). System Analysis, Design, and Development: Concepts, Principles, and Practices. Hoboken, NJ: John Wiley & Sons, Inc.





Source: http://contracting.tacom.army.mil/MAJORSYS/JLTV/Day%201%20-%200945%20-%20Prog-Over-LTC%20Petermann.ppt

Conclusions

- Feasible solutions are available to address the fuel efficiency of the military ground vehicle fleet
  - Mix of improvements oriented toward both legacy fleets versus ongoing and future programs
  - Focus on relatively low risk solutions
  - More than just technology solutions

Questions?

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